NOV 9 1923

VOLUME V NOVEMBER, 1923 NUMBER 7

THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

OFFICIAL ORGAN OF
THE AMERICAN ASSOCIATION OF INDUSTRIAL PHYSICIANS AND SURGEONS

EDITOR, UNITED STATES
DAVID L. EDSALL, M.D., S.D.

HONORARY CONSULTING EDITOR
THOMAS M. LEGGE, M.D., D.P.H.

EDITOR, GREAT BRITAIN
H. L. COLLIS, M.D., M.R.C.S.

Working Capacity and the Effect of Alternating Occupation on Output

Lead Poisoning in a Golf Professional: Case Report

The Present Status of the Problem of Resuscitation in Cases of Electric Shock and of Carbon Monoxide Poisoning

The General and Occupational Prevalence of Bronchitis, and its Relation to Other Respiratory Diseases

PUBLISHED MONTHLY BY HARVARD MEDICAL SCHOOL

EDITORIAL AND BUSINESS OFFICES : : 55 VAN DYKE STREET, BOSTON 17, MASSACHUSETTS
GREAT BRITAIN : : INDUSTRIAL WELFARE SOCIETY, 51 PALACE STREET, WESTMINSTER, S. W. 1

Entered as second-class matter, at the Post Office at Boston, Mass., under Act of March 3, 1879. Published Monthly.
Copyright, 1923, by Harvard Medical School.

THE JOURNAL OF INDUSTRIAL HYGIENE

PUBLISHED MONTHLY

VOLUME V NOVEMBER, 1923 NUMBER 7

WORKING CAPACITY AND THE EFFECT OF ALTERNATING OCCUPATION ON OUTPUT*

J. PERCY BAUMBERGER**

From the Laboratory of Physiology, Stanford University

INTRODUCTION

IN a recent article Spaeth (1) has severely criticized the use of the output rate as a measure of industrial fatigue, and points out three initial difficulties in the use of this method: "(1) The laboratory tests for fatigue are, with one exception, *qualitative* and not *quantitative;* (2) the laboratory and statistical tests detect *normal fatigue,* from which one recovers over-night or over the week-end; (3) the detection and systematic prevention of cumulative fatigue, which leads to over-exhaustion and ultimately to a breakdown (industrial psychoneurosis) and which—being common to all industry—is the most widely distributed of all industrial hazards, have been largely neglected." He also says (1) (2) that "accumulative fatigue is often associated with a high output. The output test would therefore not be applicable to such cases. Indeed, we may say that in cases of overfatigue, if the condition is not discovered until the output drops, we are shutting the barn door on an empty stall."

The purpose of this paper is twofold —namely, to point out (1) that a comparison of working capacity with output may serve as a measure of accumulative fatigue, and (2) that alternation of occupation decreases fatigue.

WORKING CAPACITY AND PERCENTAGE OUTPUT RATE

In the three processes studied the working capacity and the output rate were determined in essentially the same way. The method of determining output rate may be described as follows:

*This paper was delivered by the author before the Industrial Relations Section of the California Conference of Social Work in San Diego in 1922. Received for publication June 27, 1923.

** Dr. E. G. Martin suggested the use of the spart as a measure of working capacity and made many helpful suggestions in the course of discussions. Miss Elizabeth Perry is largely responsible for the statistical work involved.

A record of the number of pieces produced by each worker in a given length of time for each hour during the day was obtained, and from this the output rates per hour were calculated. The output rate records for each man for all the hours of all the days studied were arranged according to magnitude, and the highest 5 per cent. of the records were averaged. This average of highest output rate records was called 100 per cent. working capacity. It was found that all men, even though fatigued, at some time or other during the day feel additional stimulus or incentive to work to their utmost ability and speed, and the resulting periods of high production are often called "spurts." If a man were able to "spurt" throughout the whole day he would be reaching his maximum working capacity, or 100 per cent. working capacity, according to our terminology. The degree to which the actual output rate is less than the working capacity is the question which is to be stressed in this paper; in the accompanying charts and tables, therefore, working capacity and actual output by hours are compared for groups of workers in given processes. This can be done by determining the working capacity for each man and comparing the average actual output rate for each hour during the day with his working capacity; this gives the percentage of total working capacity reached by the output. This comparison was made by averaging the output rates for each man for each hour (as first, second, etc.) of the day, and converting this average hourly output into percentage of 100 per cent. working capacity, in accordance with the following formula:

$$100 \times \frac{\text{average output rate of John Doe for first (or second, etc.) hour of day}}{\text{100\% working capacity of John Doe}}$$

The average output rate for each hour of the day expressed in percentage of the working capacity was calculated for each man in this way. These rates were then all averaged together and the group average for each hour was obtained. Throughout the rest of the paper these figures will be called percentage working capacity, and they will be found in Figures 1, 2, 3, and 4, and in Table 2. In the figures the departure of the average output rate on the basis of working capacity from the maximum is shown by crosshatching.

Florence (3) used the average output rate of the maximum hour for the whole group of operators as a standard of comparison, and objects to the use of spurts as a basis for determining working capacity, because they are extreme deviations from the average. The spurts, however, are really a true measure of the maximum output of an individual, and it is the determination of the average approach of individuals to their maxima, that we are concerned with in this paper. This criterion (100 per cent. working capacity) is therefore not to be confused with the maximum hour used by Florence, which is based upon an entirely different determination. The maximum hour of Florence is not a measure of the average working capacity but rather a measure of the extent to which high output rates may chance to predominate in one hour of the day rather than in any other. It is probable that most individuals have their highest output in the same hour, but the output of the operators who do not would greatly diminish the maximum hour. Therefore it seems that the use of the maximum hour by Florence in his study of "Fatigue in Relation to Working Capacity" is unfortunate.

Processes Studied

Three processes were studied—namely, gathering of glass, recessing of gears, and the spin top cap operation. These three processes are considered sufficiently alike to serve as a basis for this comparison. The following descriptions will show the similarities in the three operations: In the process of glass gathering in the automatic bottle making industry (4), the workers concerned were skilled in their trade. The "gatherer" stands with an instrument 43 inches long, consisting of an iron rod with a wooden handle at one end, and at the other a clay ball on which the glass is caught. The gatherer has his back toward the bottle-blowing machine and holds the "punty" described above with both hands, allowing the glass ball to touch the surface of fused glass within a furnace. The iron rod of the punty rests on a support while the gatherer rolls it until the soft glass can form a "gob" of the size required. The gatherer then turns to the left and suspends the gob over the mouth of the mold and allows the glass to drop off. When the proper amount has fallen off, a "cutter" clips the stream of glass with a pair of shears. The gatherer then turns back to the furnace and repeats the operation. His motions are exceedingly rapid and as many as twenty-six 2-ounce gobs may be gathered in one minute.

The cutter stands on a stool at the edge of the tank and clips off the stream of the glass from the punty as it falls on the mold as described above. He then pulls a lever which brings down a plunger into the center of the mold, shaping the neck and making a depression in the glass. He then turns the table so that the bottle is partially blown automatically, greases another mold, and is ready to receive the next gob of glass. The gatherer regulates the speed of the machine as the cutter has the mold always prepared for him. The two men alternate in their two operations, each spell lasting about twenty-five minutes with a five-minute rest period between spells. In the Lynch machine the gatherer regulates the speed by touching a lever with the punty. In this machine the cutter is eliminated, and the gatherers alternate at gathering and tending to the oiling of the machine. Forty minutes of each hour is spent gathering in one spell, while twenty minutes is spent oiling and tending the machine. The men are well organized into a union, working on an eight-hour day, and are paid on a piecework basis. Most of the men have been connected with the same factory for a number of years, and the relations between employer and employee are good. The factory conditions are subject to several disadvantages which are the necessary (?) outcome of the processes. The men stand while at work within a few feet of the molten glass, facing the intense glare, while at their backs a forced draft of cold air reduces the temperature. The noise of the machines is intense and most irritating, and the danger of flying bottles and breaking glass is always present. Irritating lime, soda, and other chemicals fly through the air from the overhead tramway leading to the mixer where the flux is made.

The data on recessing of gears and the spin top cap operation were obtained from original data collected for U. S. Public Health Bulletin No. 106 (3). The process of recessing gears may be described as follows: The cog-wheel, which has already been partially cut, is placed on a trimming press, the work-

er pulls down the drill, using considerable force, and also dexterity, in pressing the drill at the proper point in order to cut out the steel and make the teeth of the cog-wheel. The process is carried on on a piece-work basis with a sliding bonus and an eight-hour day. The factory conditions were of the best as is shown by the description in the Bulletin.

The spin top lathe operation is described in Bulletin No. 106 as follows:

A good example of lathe work at the 10-hour plant is the operation known as spin top cap which forms, grooves, and finishes the top cap of the fuse. Standing before his lathe the operator takes the rough metal cap from the pile at his right and inserts it in the mounting. He turns on the power by the overhead lever, catches the side lever in both hands, lifts it, throws his body against it, and by that pressure applies the forming tool. Then vigorously throwing on and off other levers in succession, he applies the other tools in turn, indenting a recess half way down the cap, "spinning the top cap," disengaging the tools, and disconnecting the finished cap.

There is spring, movement, variety about such work as this; it lends itself to balanced rhythm. The various groups of muscles called into action, the pulling, pushing, raising, and lowering, seem to relieve and balance each other. It is hard work, yet not so hard as many less taxing but monotonous operations.

This operation was studied both for a ten-hour shift and for a thirteen-hour shift. The factory conditions in this case, as described in Bulletin No. 106, were not so ideal as in the eight-hour plant. The men were paid on a piece-work basis.

It should be pointed out that in all three cases the work involved is of a dexterous physical type. In the glass work the process is carried on for only a short time; then the worker changes to another process. Thus, there is an alternating back and forth from gatherer to cutter or from gatherer to oiler. In the spin top cap and the recessing of gears the worker continues at the same operation throughout the day. I wish to lay particular stress on this difference between the three processes, as I feel that it accounts for the higher efficiency of the glass worker as compared with the operators in the other two processes.

Working Capacity and Output

Tables 1 and 2 and Figures 1, 2, 3, and 4 show the degree to which the output rate approached the working capacity; by considering the best 5 per cent. of the records as 100 per cent. working capacity, and comparing the actual output with this figure, a comparison of the output and the working capacity is obtained. From the average of the figures for the day (Table 1) for the three processes it would seem that in the alternating occupations—namely, the glass working industry—the percentage working capacity is only 7.7 per cent. below the maximum output rate,

TABLE 1.—COMPARISON OF AVERAGE OUTPUT RATE AND WORKING CAPACITY IN EACH OF THE THREE PROCESSES STUDIED

Occupation	Number of Men Studied	Shift	Number of Hours in Working Day	Output in Percentage of Working Capacity	Percentage Output Falls Short of 100% Working Capacity
Glass gathering	48	day	8	92.3	7.7
Recessing gears	31	day	8	68.3	31.7
Spin top	10	day	10	63.2	36.8
Spin top	7	night	13	60.6	39.4

or 100 per cent. working capacity. This is not due to stereotyping, for the gatherers and cutters pay a bonus to their helpers. In the eight-hour shift recessing of gears operation, which was carried on under the best conditions, the percentage working capacity falls 31.7 per cent. below 100 per cent. working capacity; while in the ten-hour spin top cap operation it falls 36.8 per cent. below, and in the thirteen-hour night shift it falls 39.4 per cent. below 100 per cent. working capacity. It is, therefore, apparent that the degree to which the glass workers fall below their utmost working capacity is less than one-fourth as great as the extent to which the workers in the other two processes fall below their working capacity. This difference is, I believe, due to the fact that the glass workers have alternating occupations, while the other workers continue at the same operation throughout the day. The curves also show the output in percentage of working capacity (Table 2) by hours for the three processes. In the case of the glass workers the data show that the output is practically uniform throughout the day, with only a slight depression in the first hour and the last hour of the day. The other two processes, however, show the typical output curve starting low in the first hour, climbing to a peak, and then falling off toward the end of the first portion of the day. Again in the second half of the day the output commences low, climbs to a peak, and falls off at the end of the day. The dropping off at the end of the day is more pronounced in

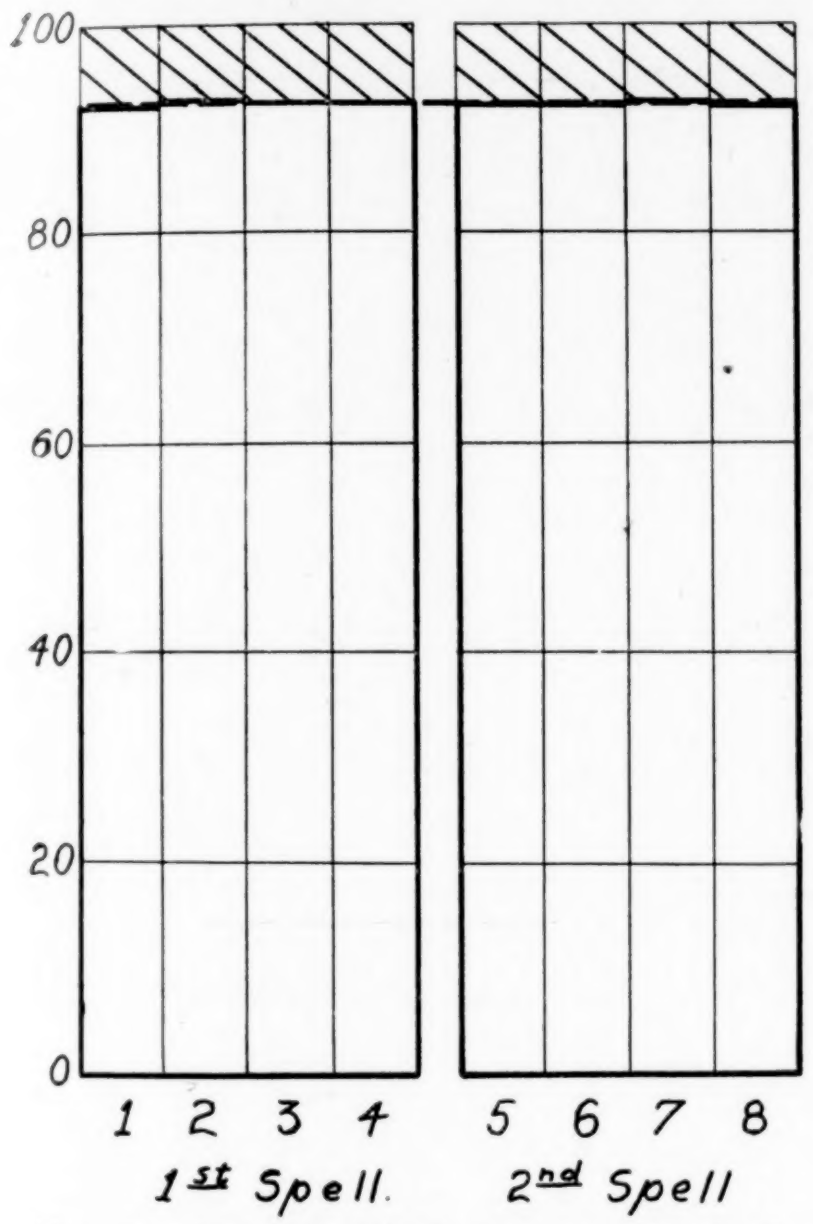

FIG. 1.—Average output rate on the basis of working capacity for glass gathering. Crosshatching shows departure of average rate from maximum.

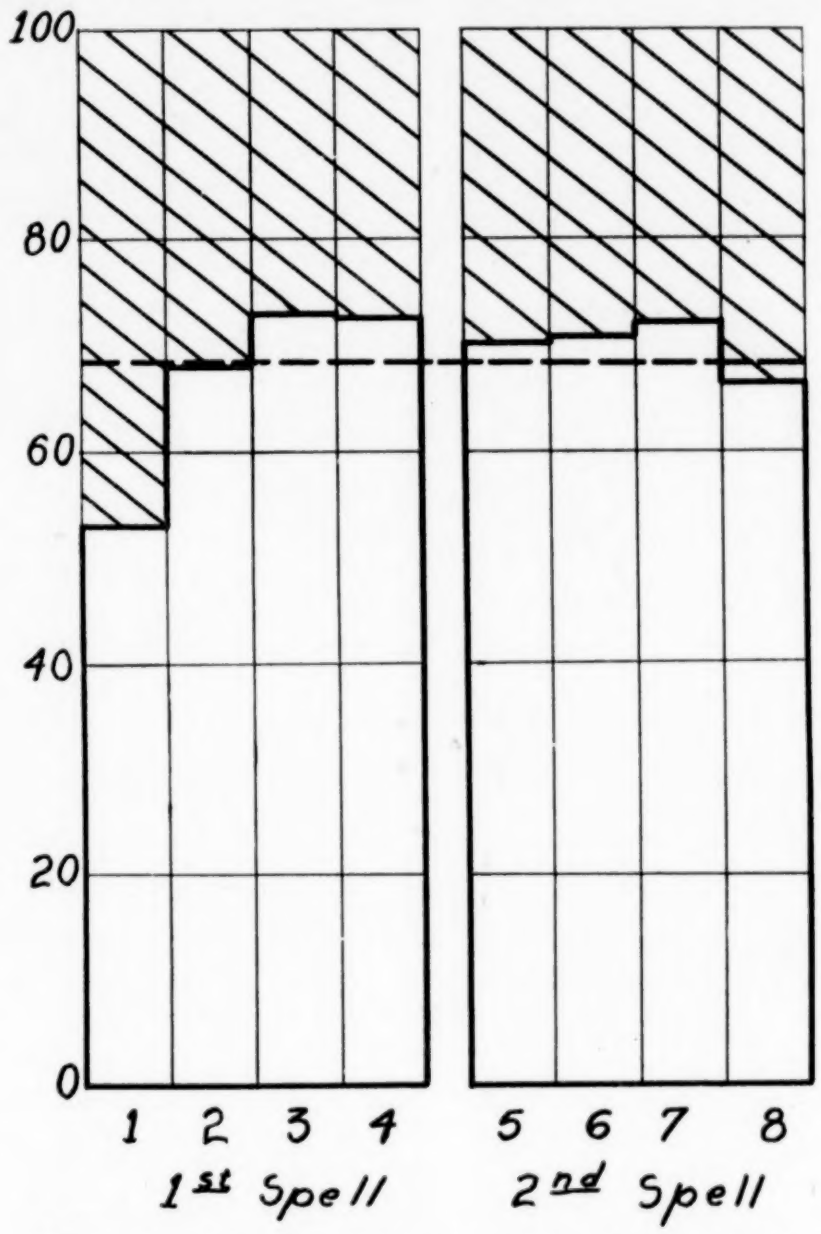

FIG. 2.—Average output rate on the basis of working capacity for recessing of gears. (See legend of Figure 1.)

the ten-hour than in the eight-hour operation; it is also more pronounced in the thirteen-hour than in the ten-hour. Such an output record has usually been described as the result of fatigue. If this is considered to be the case, it could be stated that less pronounced fatigue effects are shown in the output records of the glass blowers who work at alternating occupations than in the records of recessing of gears or the spin top lathe operation, and that with increasing length of day, as in the ten-hour and thirteen-hour shifts, the fatigue effects are more pronounced.

TABLE 2.—PERCENTAGE OF HOURLY OUTPUT ON BASIS OF BEST 5 PER CENT. OF RECORDS AS 100 PER CENT. WORKING CAPACITY

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13
						Glass Gathering (Day Shift)							
Mean	92.20	92.50	92.30	92.30	92.20	92.20	92.40	92.20					
Sigma	1.37	1.07	1.03	0.95	1.14	1.02	1.26	1.17					
P.E.M.	0.149	0.11	0.106	0.098	0.127	0.104	0.132	0.12					
C.V.	1.49	1.23	1.16	1.03	1.24	1.10	1.36	1.27					
						Spin Top (Day Shift)							
Mean	57.50	61.00	64.50	67.00	68.00	65.50	60.50	65.00	68.50	55.00			
Sigma	12.65	6.35	9.25	8.50	9.35	10.30	7.80	6.80	8.30	11.00			
P.E.M.	2.69	1.35	1.97	1.81	1.99	2.20	1.66	1.45	1.77	2.34			
C.V.	22.00	10.40	14.30	12.70	13.70	15.70	12.90	10.50	12.10	20.00			
						Spin Top (Night Shift)							
Mean	60.80	72.50	69.20	70.00	67.50	61.70	64.10	65.00	66.70	67.50	65.00	58.30	
Sigma	12.80	7.05	10.35	13.15	11.20	9.75	9.45	16.00	11.35	12.90	13.15	17.00	Practically Nil
P.E.M.	3.50	1.95	2.88	3.62	3.05	2.68	2.61	4.40	3.14	3.56	3.62	4.70	
C.V.	20.10	9.70	14.90	18.80	16.40	15.70	14.70	24.60	17.00	19.10	20.20	29.20	
						Recessing Gears (Day Shift)							
Mean	53.10	68.10	73.10	72.60	70.20	70.80	72.00	66.30					
Sigma	8.00	7.00	7.95	7.75	9.95	8.40	8.85	9.20					
P.E.M.	0.97	0.84	0.96	0.93	1.20	1.19	1.07	1.11					
C.V.	15.00	10.29	10.80	10.60	14.10	11.90	12.30	13.90					

Discussion

The data given indicate that men working at alternating occupations have an output more closely approaching their maximum working capacity than do men in the other two processes studied, in which the same operation was continued throughout the day. Some theoretical basis for this can be found when we consider the fact that fatigue is primarily central, that is, within the central nervous system, in that the seat of fatigue is the synapses. Any change in operation, although possibly involving the same muscles, would necessarily involve different synapses, and opportunity for recovery from fatigue for the previous group would be present. It is also apparent from the records that in this process of glass blowing alternation of occupation has in no way diminished the output of the men but has, on the contrary, increased it. It seems very probable, therefore, that alternation of occupation can be substituted for continuous operation in some industries, with a resulting increase in output. The extent to which this plan could be intro-

duced seems to be great, as one can readily think of a number of processes in which this could be done. For example, in the canning factory, the workers

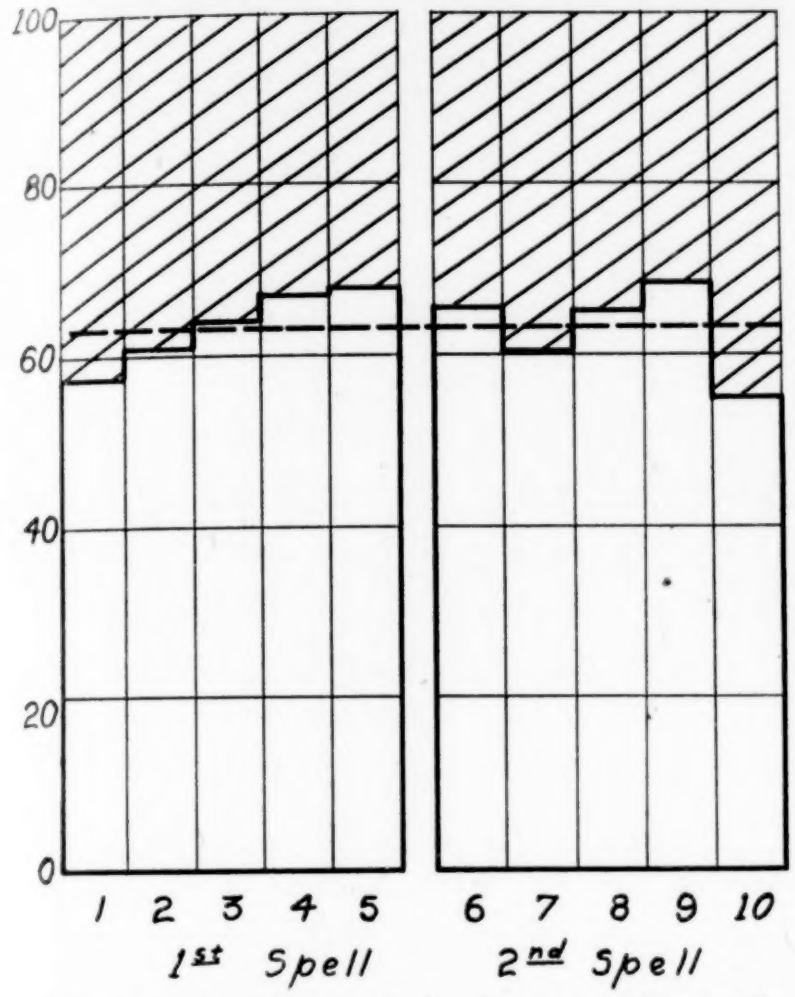

FIG. 3.—Average output rate on the basis of working capacity for spin top (day shift). (See legend of Figure 1.)

could be trained to operate two different machines and to exchange places at these machines at regular intervals of time. I feel convinced that this plan would lead to increase in output and to decrease in fatigue on the part of the men.

Recently Mr. Whiting Williams (5), in a lecture at the California Conference of Social Workers, stressed the effect on the outlook of workers of the importance attached to their jobs by the public. It would seem to be a natural deduction that the greater the extent to which the worker places his impress upon the product which he is making, the greater would be his feeling of doing a valuable piece of work, and consequently the greater would be his self-satisfaction. As industry has become more organized the work of the operators has become more and more specialized until some processes are extremely monotonous, merely demanding the repetition of the same movement over and over many times during the day. A great deal of this monotony and over-specialization which undoubtedly leads, through lack of an outlet of the craftsman instinct, to discontent, loafing and drifting (Bregman (6)), could be overcome by substituting alternating occupations for the men without any loss of the great efficiency of the industrial machine that has been built up through this specialization.

As was pointed out in the introduction to this paper, severe criticism has been made of the output method of studying industrial fatigue. It appears to me that the extent to which the output of an individual approaches his working capacity (determined by the methods described above) should be an index of the condition of the individual, provided the extent to which the actual output falls below working capacity in

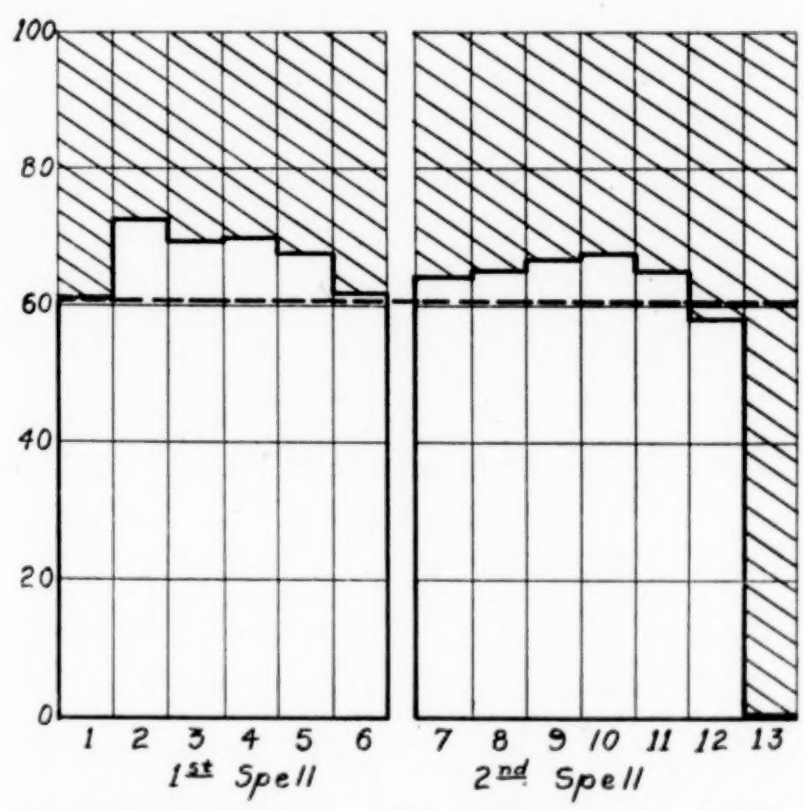

FIG. 4.—Average output rate on the basis of working capacity for spin top (night shift). (See legend of Figure 1.)

any given industry has already been determined. For example, in the glass industry, if it has been found that the

average output approaches to 92 per cent. of the working capacity of the individual, an individual falling far below this standard could be suspected of suffering from some bad condition such as poor health or accumulative fatigue; while in the processes such as the spin top lathe on thirteen-hour shifts, it would be necessary for a person to fall far below 62 per cent. of his working capacity before being considered unfit. This criterion could be worked out for each industry and could be readily determined for each individual by studying his best output records, as it is likely that even when suffering from accumulative fatigue an individual may spurt for short intervals during the day, under special incentives, and thus indicate his working capacity.

The average percentage working capacities for two industries may be compared hour by hour and give an index of the degree to which maximum output is obtained in each. This comparison is legitimate if the number of operators concerned is large, because it is based on a standard measurement, namely, the average working capacity. Florence compares the "relative hourly approximation to maximum production" in two industrial plants, but this seems to me to be merely a comparison of differences, in the two industries, in the degree of grouping of high output in the maximum hour. By the use of the percentage working capacity as a criterion the two plants could be compared, as the basis of comparison is the physiological maximum working capacity.

Conclusions

1. The average of 5 per cent. of the highest output records for each individual is termed 100 per cent. working capacity for the individual.
2. The average approach to maximum working capacity is studied in three occupations for each hour of the day.
3. The output in an occupation in which the workers alternate in two operations shows much closer approach to maximum working capacity than occurs in two operations which are continuous.
4. It is suggested that alternation of operations would lead to increased output in many industries.
5. The determination of the working capacity of individuals and of their average departure from it is suggested as a means of studying fatigue in the individual.
6. The use of percentage working capacity in comparing output in two different plants or operations is recommended.
7. Florence's (3) use of the maximum hour is criticized.

BIBLIOGRAPHY

1. Spaeth, R. A.: The Prevention of Fatigue in Manufacturing Industries. This Jour., 1919-1920, *1*, 435.
2. Spaeth, R. A.: The Problem of Fatigue. *Ibid.*, p. 22.
3. Goldmark, J., and Hopkins, M.D.: Studies in Industrial Physiology: Fatigue in Relation to Working Capacity. 1. Comparison of an Eight-Hour Plant and a Ten-Hour Plant. U. S. Pub. Health Bull. 106, Feb., 1920.
4. Baumberger, J. P., Perry, E. E., and Martin, E. G.: An Output Study of Users and Non-Users of Tobacco in a Strenuous Physical Occupation. This Jour., 1921-1922, *3*, 1.
5. Williams, W.: "What's on the Worker's Mind." Scribners, 1920.
6. Bregman, A.: Monotony and Industrial Unrest. Survey, 1923, *49*, 552.

LEAD POISONING IN A GOLF PROFESSIONAL: CASE REPORT*

C. M. Davis, M.D.
Cleveland, Ohio

THE occupation of golf professionals does not seem, at first glance, to carry with it a risk of lead poisoning. It has, however, a dangerous side-line in the practice, which is common among professionals and their helpers, of re-painting used golf balls for re-sale as practice balls. The method employed involves unusual exposure since the painter uses no brush but merely takes a handful of white lead paint and works it into the uneven surface of the ball by rotating the latter between the palms. In the case to be reported, this practice was the only known exposure to lead.

Case Report

D. O., a Scotchman, married, age 43, had earned his living on the golf course as helper or professional since he was 12 years of age. His family history was unimportant except for the occurrence of giant hives (from which he also suffers occasionally) in several members on the maternal side, and in one child.

He had had no illnesses of note in childhood, he denied venereal infection, and, aside from the condition for which he sought relief, he had had no illnesses in adult life other than three mild attacks of tonsillitis unaccompanied by any rheumatic symptoms, about seven years previous to the illness here reported.

When he was 12 years old, after his first day's work painting balls, he became acutely ill, with excruciating headache, nausea, vomiting, constipation, and abdominal cramps and tenderness. Recovery occurred within a few days, but further attempts to do golf ball painting resulted promptly in similar though less severe illness, so that for several years he did no more of this work.

During the past twelve or thirteen years he has painted a few balls from time to time, and during the last five years he has painted more and more each year, chiefly in off seasons and on winter evenings. Since no acute illness resulted, he did not associate with ball painting the pains in his limbs which began to annoy him; he considered that they were due to rheumatism, and the abdominal cramps which simultaneously became frequent, he ascribed to indigestion.

The pains were most constant in the spring, and in 1919 they were of such severity that he consulted a physician at whose advice his tonsils were enucleated and most of his teeth extracted, several of which were dead, and many in poor repair. No relief was obtained, either immediately or later, and his suffering and disability were considerable during that and the succeeding two summers.

In the winter of 1921 to 1922 the burning of the hotel at the resort where he was employed as golf professional put an end for the time being to his teaching activities, and during the few weeks remaining before the opening of the spring season he occupied himself with painting balls and making clubs, painting in all between 2,000 and 3,000 balls.

Early in March the pains in his limbs and back recurred with unusual severity, and he began to have pains in his shoulders and upper arms as well. By

*Received for publication August 6, 1923.

May he could no longer follow his occupation, for in addition to the pains a distinct loss of power in the lower limbs had appeared, first noticed as difficulty in going upstairs. As at previous times, he had no fever. Heat, salicylates in adequate dosage, and atophan gave no relief.

Physical examination (June 7) was negative except for the complete absence of patellar reflexes. There was no swelling nor redness of the joints, no tenderness of the nerve trunks nor of the muscles, and no limitation of motion. Four weeks later, during an attack of giant hives, both knees became suddenly and painlessly swollen, without heat or redness. Both the swelling and the hives, however, disappeared within forty-eight hours.

The Wassermann reaction (blood) was negative; the blood chemistry was normal, as was the urine which, however, was not examined for lead. The blood count (red and white cells) was normal and the hemoglobin 85 per cent. (Sahli); careful search of several slides showed only rarely a stippled red cell, but there was a definite lymphocytosis, and a number of mononuclears showed basophilic granules. The differential count was: polymorphonuclears, 52 per cent.; large mononuclears, 6 per cent.; small mononuclears, 27 per cent.; mononuclears with basophilic granules, 12 per cent.; transitionals, 3 per cent., and eosinophils, 0 per cent. The number of cells counted was 200.

The patient was advised to discontinue painting, and iodides were administered. The pain gradually disappeared, muscular power slowly improved, and in August he was able to resume teaching.

At the present time (one year later) he reports that he has remained entirely free from pain and abdominal cramps, and that he feels better than he has for several years. He still notices that his limbs tire more easily than they formerly did, although the improvement in this respect has been continuous. The knee jerks, which could not be elicited for about three months, are still somewhat below normal, especially the left. The blood picture is normal except for a slightly low proportion of polymorphonuclears (58 per cent.) and an occasional mononuclear with basophilic granules.

THE PRESENT STATUS OF THE PROBLEM OF RESUSCITATION IN CASES OF ELECTRIC SHOCK AND OF CARBON MONOXIDE POISONING

CECIL K. DRINKER, M.D.

From the Department of Physiology of the Harvard School of Public Health

THE problems of resuscitation presented by the field of industrial hygiene are somewhat narrower than those found in the general fields of safety and of medical practice. At the same time, it should be understood that the most important measures of treatment available are directed toward restoration of normal respiration and circulation, and that consequently many of the principles of treatment are interchangeable for all the different emergency conditions which face the physician and the hygienist.

The two vitally important conditions in which industry is interested are electric shock and carbon monoxide poisoning.

ELECTRIC SHOCK

That death from electric shock is an extraordinarily frequent occurrence in the United States is painfully obvious to anyone reading our daily papers. Few people, however,—and this is true of the medical profession as well as of the laity—have an adequate idea of the various things which may happen when the body becomes part of an electric circuit. Disregarding the matter of burns, which do not constitute the acute emergency we have to consider, let us list the bodily phenomena that attend electric shock and then discuss the bearing which these phenomena have upon resuscitative measures.

A. *Effects upon the Nervous System.*—The medical literature, from time to time, contains references to anesthesia produced by means of electric currents. For many years physiologists have recognized that while a nerve trunk is conducting a current of electricity it is unable to conduct a nerve impulse. The area of block imposed in this manner seems to do the nerve no damage unless the current is of considerable strength. That is, one may totally block impulses in the nerve of a cold-blooded animal for many hours, yet, immediately upon cessation of the blocking current, impulses pass through the length of nerve involved without the slightest evidence of abnormality. It is probable that the induction of local anesthesia by means of electric currents depends upon the production of nerve block in a quite similar manner, and it seems equally probable that the anesthesias, paresthesias, paralyses, and unconsciousness which are observed in electrical accidents are but more serious expressions of the same type of effect. We may conclude, therefore, that nervous tissue is apparently specifically susceptible to the action of the electric current, and that the effect produced may vary between no injury whatsoever and damage so considerable as to prevent the recovery of function during the period of life following removal from the current. There is practically no knowledge of what happens in nervous tissues as a result of electric shock, the minute hemorrhages and minor altera-

tions in cerebral and other nerve cells observed being quite as apt to be due to the asphyxia attending death from shock as to the action of the current *per se*.

The important things for us to realize are that normal nervous activity may be abruptly interrupted by means of the electric current without any particular damage to the tissue itself but with the possibility of causing death to the victim unless the influence is removed, and that, extending beyond such simple situations as this, we have the possibility of nervous phenomena of variable duration and severity, depending upon varying degrees of damage to the nervous system. It is often impossible to dissociate these latter effects from the results of the prolonged periods of asphyxia which so often accompany electrical accidents. Not infrequently, for example, periods of unconsciousness following shock probably express the added effect of asphyxia, unconsciousness being initiated by shock and continued as a result of oxygen lack in the cerebrum, a condition similar to that seen in gas poisoning.

With these facts in mind, it is easy to understand that electric shock may inhibit respiration, and that the effects produced may vary between momentary cessation of breathing, reflecting no real damage to the system of nerves involved, and degrees of damage from which recovery is quite impossible. Respiration depends upon the rhythmic discharge of nerve impulses from a group of nerve cells in the medulla oblongata. In normal breathing these cells are stimulated by the carbon dioxide content of the blood and by certain impulses reaching them from the lungs. Through nerve paths of varying complexity, the respiratory center is connected with the muscles of respiration. It seems probable that respiratory stoppage as a result of electric shock is due to a direct effect of the current upon the cells of the respiratory center, though we have no certain evidence of this, and that under the usual conditions of electrical accident the cells of this center will resume their property of rhythmic impulse discharge after a short time, provided the amount and quality of the blood reaching them during their period of inhibited activity remains good. This is really the crux of the resuscitation problem in electric shock, and we will return to it after discussing the second important feature of shock—namely, the effects upon the circulatory system.

B. *Effects upon the Circulatory System.*—There is every reason to believe that the real problem of the circulation in electric shock is concerned with the heart alone. While in serious cases nervous tissue involved in maintenance of normal blood flow may be affected, it seems improbable that such effects are either grave or lasting.

Many years ago it was shown that a brief and weak electric stimulus applied to the heart muscle, in experiments upon animals in which the heart was exposed, caused fibrillation of the heart muscle. When this condition involves the muscle of the ventricles, the pumping function of the heart is instantly lost. The muscle ceases to contract in an orderly pulsatile fashion and develops a disordered fibrillary twitching from which recovery is difficult. In cats, ventricular fibrillation occasionally stops spontaneously. In dogs this is practically never the case, nor have we remedial measures which can be relied upon to check the condition. When fibrillation is established in cats, almost any highly abnormal stimulus may restore normal rhythm. Of such measures, actual massage of the heart with the hand, particularly if it causes emptying of the heart chambers and so

keeps up the nutrition of the heart itself, has in my experience been most successful. That ventricular fibrillation occurs spontaneously in man has been proved within recent years, and it is probable that sudden deaths of cardiac origin are frequently referable to it. Quite recently a human case has been reported in which periods of ventricular fibrillation were followed by periods of return to normal, so that it seems possible that in man ventricular fibrillation is not so inexorably persistent as we have seen it in the dog following direct electrical stimulation of the heart.

As one reads the literature upon the subject, one is impressed by the large amount of discussion which surrounds the question of the strength of current which will kill man. Voltages as low as 70 have certainly been fatal, and I find reference to one death from an alternating current of 50 volts. There are, of course, many records of death due to contact with the ordinary 110-volt lighting circuits which we employ in our houses. Such questions are not of much direct importance for us except in so far as these deaths from low voltage emphasize the fact that if the heart is in the path of the current very little is required to kill. This is easy to understand when we realize that on direct application to the ventricular muscle of animals currents of 2 to 3 volts will induce fibrillation, and that 15 volts at 30 cycles will readily cause fibrillation in the dog if electrodes are applied to the outside of the body in such a manner as to cause the current to pass through the heart.

When ventricular fibrillation occurs, the heart is no longer beating and all the tissues of the body, consequently, are deprived instantly of fresh blood bringing the normal supply of oxygen. Nerve cells are peculiarly susceptible to oxygen deprivation but vary somewhat in susceptibility. In animals it has been shown that complete deprivation of blood cannot be withstood by nerve cells past the limits displayed in the following table:

Cerebrum, small pyramidal cells	8 minutes
Cerebellum, Purkinje's cells	13 minutes
Medullary centers	20 to 30 minutes
Spinal cord	45 to 60 minutes
Sympathetic ganglia	1 hour
Myenteric plexus	3 hours

If electric shock does not affect the heart but does cause cessation of breathing, total deprivation of oxygen will not occur with such extreme abruptness. The oxygen taken from the blood in different parts of the body at any one time being a variable quantity, circulation of blood containing some available oxygen will continue for a time. When the breathing alone is interrupted—if we may transfer our experience with animals to man—the heart will continue to beat for from five to eight minutes, and it is probable that nervous degenerations of irrecoverable nature will not take place for almost an equal period of time following total cessation of beat. While the heart which has ceased beating on account of asphyxia does not readily start again unless attacked very directly, there is always a possibility that well-applied artificial respiration may have even this result, and consequently, in early cases, this measure should never be withheld even though there is no evidence of heart beat.

Carbon Monoxide Poisoning

The gassed patient presents a far more complex problem than does the victim of electric shock. Carbon monoxide combines with the hemoglobin of the blood, excluding oxygen from the hemoglobin molecule and causing death by

oxygen deprivation. The entire process may be very slow. When death occurs, respiration fails before the heart beat ceases; but if at the time respiratory failure takes place the individual is removed from the gas-laden atmosphere and is given artificial respiration, normal breathing can be restored. As a practical matter, it seems as if cases illustrating such a course are very infrequent. In carbon monoxide poisoning, when breathing stops death is far nearer than is the case in electric shock. The latter condition, if ventricular fibrillation is not present, has the advantage, at the moment of respiratory cessation, of a heart unharmed by an antecedent period of oxygen lack and of a well-oxygenated blood supply. The heart of the gassed patient whose breathing stops has already experienced a gradually increasing period of oxygen lack, and the blood has a diminished total oxygen content. In view of these facts, it is not surprising to find that authentic reports upon gassed persons who have recovered but who were not breathing when found are exceedingly hard to discover.

When help arrives, the gassed patient who needs careful medical attention will be found unconscious, and, as a rule, breathing in an abnormal manner. Experiments have shown that as gassing progresses the breathing first becomes deeper and more rapid. After a period of varying length, dependent upon the concentration of carbon monoxide in the air, this stage is replaced by shallow rapid breathing which becomes irregular and finally ceases. All sorts of variations in rhythm may be seen but the facts of the situation are that in the early, less serious stages of gas poisoning breathing is ordinarily excessive, and that a period of diminished breathing precedes total stoppage. Artificial respiration is thus less apt to be needed in gas poisoning than in electric shock. While rescue crews should be thoroughly familiar with the prone pressure method of resuscitation, the emergency offered by the gassed patient is less an emergency demanding instant, heroic measures than it is one requiring an intelligent appreciation of the situation and adequate means for attacking the fundamental condition involved—namely, the partial saturation of the hemoglobin molecule by carbon monoxide.

The questions of nerve-cell vulnerability under oxygen deprivation, which we have mentioned in our discussion of electric shock, are obviously of equal importance in gas poisoning. When we appreciate that cerebral cells are twice as susceptible to oxygen lack as are the cells in the medulla, one of the reasons for the prolonged periods of unconsciousness and for the mental derangements which sometimes follow gassing becomes clear.

Resuscitation after Electric Shock

From our discussion of the pathological physiology of serious shock it is evident that we may be dealing with an individual in one of several conditions:

1. Respiration may have ceased but the circulation may be normal.
2. Respiration and circulation may have ceased at the same time, the ventricles of the heart being in fibrillation.
3. Respiration may be present and the heart stopped, *i.e.*, in ventricular fibrillation. Such a respiratory condition would be exceedingly transient and in all probability unappreciated.

There is no doubt that the first measure to be applied in any one of the three conditions is artificial respiration. If the action of the heart has not been disturbed, persistent use of artificial respi-

ration will often bring about recovery in individuals in the first group. It is conceivable that in occasional cases belonging to the second and third classes spontaneous cessation of ventricular fibrillation may occur. In the presence of adequate artificial respiration, there is no reason in such an event why entire recovery of the patient should not take place. There is a possibility, though a remote one, that the thoracic pressure utilized in artificial respiration may have a direct cardiac effect remotely similar to the massage which we have spoken of as sometimes breaking up ventricular fibrillation in the cat. Hypodermic injections of various types, no matter how impressive they may appear, give no promise of influencing the result.

Recently, both in this country and in England, it has been contended that the shocked individual is more apt to recover—more apt to start independent respiration—if subjected to what has been called counter-shock. This idea owes its genesis to the statement that men who are seriously shocked and fall from high places are more apt to revive than those who are shocked while on the ground. On the basis of this contention, it has been recommended that shocked individuals be lifted and allowed to drop, pounded on the feet, punched—vigorously and abruptly subjected to severe sensory stimulation. There is no known justification for such procedures. Sensory stimulation ordinarily causes respiration to become quickened. The rapid breathing of the person in pain is familiar to us all. It is also possible to obtain a sudden brief cessation of respiration from sensory stimulation, and many of us have experienced this when suddenly subjected to great heat or cold. Neither reaction is impressive enough to cause us to feel that counter-shock is a matter of the slightest importance to the breathing of the victim, and it is quite unlikely that the heart is affected by such measures. It seems more probable that the difference in effect—if a difference actually exists—of the electric current that reaches a man upon a pole and of the same current reaching a man upon the ground resides in the abruptness with which the shocked person on the pole drops away from the source of current. It should also be pointed out, however, that men who work upon poles are very apt to receive the current through the arms or upper part of the body—sites of reception dangerous to both respiration and heart.

There is no doubt that the best type of artificial respiration of which we now have knowledge is the familiar Schäfer prone pressure method. I need not describe the method of application since it is thoroughly familiar. I do wish, however, to discuss certain matters of fundamental importance to us. Breathing depends upon a rhythmic increase and decrease of the negative pressure in the thorax. Air is thus sucked in and passively blown out. The prone pressure method of artificial respiration attempts to imitate this normal negative pressure type of breathing. The operator compresses the chest of the individual and air is forced out of the lungs. On release of the thoracic compression, the chest expands to its normal size and air is drawn in. Inspiration is accomplished by the passive part of the act. There have been many efforts to determine how much air can be moved per minute by this maneuver but the figures now available are not satisfactory since they have been obtained from subjects in states not comparable to that for which this method of artificial respiration is used. It is possible, in normal individ-

uals who are asked to breathe very vigorously for a brief period of time, to obtain a condition of apnea which, under suitable conditions of breathing, may last as long as eight minutes. Such prolonged periods are attained by breathing pure oxygen. If, during a period of apnea of this type, one endeavors to determine the amount of air that he can get into the chest at each respiration, his results are disappointingly low. The maximum respiration volume under these circumstances is 150 to 200 c.c. per breath. At rest, an adult of ordinary size requires in the neighborhood of 500 c.c. of air at each inspiration. Judged by this criterion, it appears as if the prone pressure method were woefully lacking. If one tries the method upon a subject who is breathing normally, he obtains a degree of air movement very comparable to that used by the subject in ordinary breathing. Apparently during apnea or following enforced breathing the chest is, as it were, jammed, the force of the operator being automatically resisted. In the breathing subject, on the other hand, the individual merely falls into the rhythm of the operator, moving the air at the rate required at the moment. There is no doubt, however, that even if the air movement obtained by the prone pressure method is low, benefit must result from its use; but there seems, on the contrary, good evidence that air movement during this procedure is not low. We have records of persons who have ceased breathing but whose hearts have been operating normally, and such patients have been kept alive for long periods by means of the prone pressure method. Results of this sort could not be obtained if, in the non-breathing person, we were unable to obtain a larger air movement than occurs in experiments upon apneic subjects. The method has shown that it will sustain life—the best evidence that its efficacy is great.

I have attempted to evaluate the prone pressure method in persons recently dead, but the very rapid loss in body resiliency following cessation of circulation renders such tests unsatisfactory, an essential for the success of the prone pressure maneuver being a normal degree of bodily elasticity. My experience in this matter is the same as that of other investigators who have attempted the same experiment. It is thus clear that, as yet, we do not possess real physiological data upon the efficiency of the prone pressure method of resuscitation, though we are reasonably certain that this efficiency is far above that obtained by experiments upon apneic subjects and upon cadavers. This conclusion is permissible because the method has shown itself able to sustain life. We require, however, observations upon the amount of air moved by this method in persons whose hearts are beating normally but whose respiration has ceased. Cases of this type are frequently seen in hospitals, and, owing to the simplicity with which the necessary measurements can be made, we are certain eventually to obtain the necessary figures.

The issue is of more than academic interest since manufacturers of apparatus for artificial respiration do not hesitate to claim that the actual performance of the prone pressure method is found in the figures which I have given for apneic persons, and this low estimate is then compared with the nozzle delivery of the particular apparatus supplied by the manufacturer. To the uninstructed individual, the only answer seems to be to buy the device—a decision unfortunately based upon fallacious measurements.

There are many arguments for and against the use of mechanical appliances for artificial respiration. Almost without exception, these devices attempt to blow air into the lungs by the action of positive pressure and then to suck it out by the use of negative pressure. Physiologists have maintained artificial respiration in animals by such methods for several hundred years, with the exception that, in the case of a physiological experiment, the trachea is cannulated and the pump employed is connected directly with it. In human resuscitation by a mechanical device, air must be driven in through the nose and mouth via a face mask. This essential situation gives much opportunity for trouble. In the first place there is ready chance for obstruction in the nose, the pharynx, and lower down in the respiratory passages. Furthermore, it is very difficult to devise a face mask which can be applied quickly and which remains tight during the positive blast of the instrument. The suction which accomplishes expiration promptly seals the mask around the face, and the withdrawal stroke of the pump thus tends to produce a vacuum in the lungs—a situation the reverse of beneficial for the patient.

If mechanical devices—which are invariably expensive—are to supersede the prone pressure method of artificial respiration, they must show themselves to be really superior to this method. That is, appropriate experimentation must demonstrate that such appliances oxygenate the blood and remove carbon dioxide in a reasonably normal manner. We have made extensive investigations upon animals in order to find out whether or not various popular artificial respiration devices accomplish these ends, and we have uniformly found the devices unreliable. Occasional aëration of the blood is obtained. At other times, in spite of the most careful adjustment of the animal, it proves impossible to introduce enough air. There is no doubt that we need a machine to supply artificial respiration which can be used on human subjects for long periods of time. Not infrequently in hospital practice emergencies arise which make such treatment necessary. A notable example is seen in the post-diphtheritic paralyses of children. Situations of this sort, however, are far different from the surroundings attending accidental electric shock. It is necessary in all cases of suspended respiration to act instantly, and there is no doubt that knowledge of the prone pressure method of respiration on the part of fellow-workmen offers the best chance for prompt successful resuscitation. When the problem of sustaining life by a long period of artificial respiration arises, then mechanical appliances may have a place, but my examinations of apparatus now upon the market have not convinced me that the ideal appliance is as yet available.

Resuscitation in Carbon Monoxide Poisoning

I have already mentioned the fact that the victim of carbon monoxide poisoning requiring medical aid is practically always breathing when found, though this breathing in the more serious cases may be weak and inefficient. Owing to the fact that prolonged partial saturation of the blood with carbon monoxide results in a diminution in its oxygen-carrying capacity, such patients have suffered from periods of oxygen lack of varying length. The great problem in resuscitation consists in removing the carbon monoxide from the blood with the greatest possible rapidity. It has been known for a long time that if the

lungs are deeply ventilated with pure air or with oxygen, the blood will give up carbon monoxide with fairly great rapidity, the oxygen again taking its place in the hemoglobin combination. The problem becomes, therefore, that of getting as much oxygen as possible into the alveoli of the lungs, and to this end oxygen inhalations have been recommended. It has also been suggested that oxygen be pumped into the lungs by any of the devices now used for artificial respiration. Neither of these maneuvers is satisfactory. The first fails because the breathing of the victim of serious poisoning is invariably shallow and inefficient, and pure oxygen does not stimulate respiration. The second may be successful if the operator is lucky enough to make adjustments which result in really supplying the lungs with the oxygen delivery of the apparatus, but, as has been said, this is an attainment upon which no reliance can be placed.

The normal stimulus for respiration is the carbon dioxide delivered to the circulating blood by the body cells. Examination has shown that in carbon monoxide poisoning the normal blood content of carbon dioxide is reduced, the individual apparently ceasing to breathe through lack of appropriate stimulus for the cells of the respiratory center. This diminution in the carbon dioxide of the blood is, of course, not present during the period of rapid respiration in the early stage of poisoning, but it is present in the later serious stages. Many observations, both in the physiological laboratory and in the clinic, have shown that respiration can be greatly increased by adding carbon dioxide to the air breathed. If the amount added is from 7 to 10 per cent., headache will frequently follow. In concentrations of 5 per cent. and below, this symptom rarely appears, and if it does it is of negligible severity.

In consequence of the facts that the breathing may be enormously increased by adding carbon dioxide to the atmosphere inhaled, and that high concentrations of oxygen force the rapid elimination of carbon monoxide, the modern treatment of carbon monoxide poisoning consists in utilizing inhalations of 5 per cent. carbon dioxide in 95 per cent. oxygen. A normal person, breathing this mixture, finds that his respiratory volume per minute rises from 9 or 10 to 30 or 40 liters. The beneficial effects of a similar type of change in a person poisoned from carbon monoxide are obvious. Since this treatment was advocated it has been accused of danger because of "over-stimulation of the heart." I do not know what this term means. We have no description of any such condition either in physiological or medical literature, and one can but feel that such an accusation, in the absence of detailed descriptions of experiments upon animals or illustrative cases in man, represents a vague and ill-founded distrust of a therapeutic measure already recognized as safe. Since the oxygen-carbon dioxide method of resuscitation came into general use in this country a year or more ago, we have had nothing but encouraging clinical reports in regard to it. In addition, in this city, we have had opportunity to see that inhalations of air enriched with carbon dioxide offer a most useful means of freeing the blood from ether following prolonged etherizations, and that individuals, whose circulations are in exceedingly bad condition, are benefited by the procedure.

It should be added that the oxygen-carbon dioxide treatment requires specially constructed apparatus, and that information upon apparatus which

has passed careful tests may be obtained from the American Gas Association, 342 Madison Avenue, New York City. Needless to say, rescue crews although having such apparatus available should, nevertheless, be instructed in the Schäfer method of artificial respiration. If a patient is not breathing when found, one member of the rescue squad may apply the face mask while another performs the Schäfer method of resuscitation. In this way, a gas mixture designed to stimulate breathing and to hasten the removal of carbon monoxide will be introduced into the lungs at the earliest possible moment.

The question has been asked as to whether this modern method of resuscitation is useful in such emergencies as drowning and electric shock. Obviously neither of these conditions imposes the state of affairs surrounding carbon monoxide poisoning, and they do not seem to require the new treatment. It may be said, however, that the inhalations proposed will stimulate breathing if any maneuver is able to do so, and it is, therefore, probable that inhalations may be of value in these emergencies.

THE GENERAL AND OCCUPATIONAL PREVALENCE OF BRONCHITIS, AND ITS RELATION TO OTHER RESPIRATORY DISEASES*

EDGAR L. COLLIS, M.A., M.D., M.R.C.P.

Mansel Talbot Professor of Preventive Medicine, Welsh National School of Medicine

THE trite observation that familiarity breeds contempt is essentially true with regard to the outlook upon chronic bronchitis; those afflicted are inclined to accept the complaint as inevitable, as something troublesome but not serious. Those called upon to treat it do not find it sufficiently interesting to study closely. At a hospital it tends to be disregarded with an outpatient mixture, to which in the home a liniment may be added. Yet bronchitis stands high not only in the list of causes of death, but also among causes of invalidity. Herein it contrasts with both phthisis and pneumonia; these diseases also stand high among the great causes of death; but they do not contribute equal quotas to the great sum of invalidity. Records in England and Wales show that when morbidity and mortality are taken together, bronchitis is the most important of all diseases; and, further, judging from the trend of mortality records in recent years, that it is at the same time a most preventable disease.

MORBIDITY

Information is strictly limited regarding the amount of sickness caused by bronchitis. Some idea may be obtained from the data stated in Table 1, but exact information, such as is forthcoming with regard to mortality, is lacking. A rough estimate of the amount of sickness due to bronchitis annually may be arrived at by ascribing to it two-elevenths of all sickness. The minimum amount of total sickness under the English National Health Insurance system represented, during 1922, a sum of 375,000 years. On this basis bronchitis accounted for sickness amounting to 68,000 years. This total refers only to insured persons, however, and not to those at the end of life, when the tendency to suffer from bronchitis is most pronounced. Probably an annual total of 80,000 years of sickness due to bronchitis among adults is a fair presentation of the invalidity occurring from this cause in England and Wales.

When some clue as to causation is sought from the distribution of this type of sickness by age, sex, occupation, and geographical position, we are faced with an absence of detail. In any efforts that have been made—for example, by

TABLE 1.—PROPORTION OF (1) ALL SICKNESS, AND (2) ALL DEATHS DUE TO RESPIRATORY DISEASES, 1916, ENGLAND AND WALES

Cause of Death[1]	Proportion per 1,000 Cases		Cause of Sickness[2]
	Deaths	Sickness	
Bronchitis	85.3	181.3	Bronchitis, bronchial and nasal catarrh
Tuberculosis all forms	106.4	12.2	Tuberculosis, all forms
Pneumonia all forms	74.5	69.2	Pneumonia and other diseases of the respiratory system

[1] Eighty-Third Annual Report of the Registrar-General for England and Wales (1920). H. M. Stationery Office, 1922.

[2] Newman, Sir G.: An Outline of the Practice of Preventive Medicine. Cmd. 363, 1919, p. 29.

*Received for publication July 27, 1923.

investigators of the Industrial Fatigue Research Board—to ascertain sickness rates distributed by age and occupation, bronchitis has been classed together with other respiratory affections. Since grave error might be introduced by attempting to calculate the prevalence of bronchitis by taking it to be some definite ratio of the total respiratory invalidity, no useful purpose would be served by presenting the results of these investigations here.

TABLE 2.—NUMBER OF CASES OF INVALIDITY, CAUSING ABSENCE FROM WORK FOR AT LEAST ONE WEEK, PER 1,000 PERSONS PER YEAR AMONG MEMBERS OF CERTAIN AMERICAN SICK-BENEFIT ASSOCIATIONS FOR 1921

Cause of Disability		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bronchitis	1920	21.6	19.3	12.0	8.5	6.3	3.2	3.8	3.8	4.1	3.8	6.7	6.2
	1921	7.7	11.4	6.8	5.6	4.2	3.0	1.9	4.7	4.6	7.3	7.5	7.3
Pneumonia	1920	15.8	12.5	2.5	4.7	5.0	1.9	1.6	2.0	1.6	3.2	2.4	4.9
	1921	4.4	3.6	4.9	3.9	1.5	0.5	1.0	0.9	1.3	2.1	2.8	3.5
Phthisis	1920	2.5	1.1	3.0	0.9	0.9	2.3	1.4	1.4	1.8	3.0	3.1	2.8
	1921	2.5	1.5	2.8	2.5	2.0	1.9	2.1	2.1	0.7	1.5	1.7	1.9
All diseases and conditions	1920	275.0	326.7	126.0	103.9	76.7	67.3	67.1	60.1	56.2	76.4	85.7	106.1
	1921	134.0	152.5	128.5	110.6	88.4	76.6	70.6	87.9	86.7	81.6	94.3	105.2

Rather more definite information is given in some inquiries regarding morbidity among wage earners in the United States (1). Here the number of cases of sickness from specific causes, lasting one week or longer, has been classified according to the month of occurrence; but the statistics suffer from not being distributed by ages, nor being weighted for length of disablement. If, however, the age distribution of the wage earning group is taken as fairly normal, then the figures give some idea of the frequency of invalidity experienced (see Table 2). The tendency of disability on account of bronchitis and pneumonia to be high in a period of epidemic influenza is manifest in the records for the early months of 1920; the winter exacerbation and summer fall for these two diseases is also noticeable. Neither of these points is manifested in the records for invalidity due to phthisis.

Mortality

Objections may be raised to taking death rates from bronchitis at different periods as a comparative measure of the prevalence of the disease at each period, on the ground that the standard of diagnosis may have altered. Such criticism has been levelled at every effort to deal epidemiologically with disease entities; it fails to become vocal only when all deaths are under review; then the attack is changed and directed against estimates of the population at risk. These objections are here disregarded, and the condition certified as bronchitis since 1860 is considered to be the same clinical disease; the only concession made is the introduction of data referring to pneumonia and phthisis, the two main diseases concerning which difficulties of differential diagnosis might arise. The differences in the behavior of the records relating to these three causes of death suggest that three different disease entities are represented, which, while they may overlap, have in the main their prevalence portrayed by the data. In order to eliminate the acute bronchitis of early life, the data considered hereafter refer to persons aged 15 and over.

Male and Female Mortality.—The male mortality from bronchitis since 1860 has throughout life exceeded that of females; but the difference is less pronounced than in the case of pneumonia and far less pronounced than in the case of phthisis. Mortality from bronchitis after 1861-1870 first rose for one decennium, but since then it has steadily declined; this statement applies to both sexes. The fall which has occurred has tended from age 35 onwards to be slightly greater for males than for females, hence the death rates for the two sexes have been approximating; indeed, they became practically equal in 1911 to 1920, for which period the ratio was 497 for males and 503 for females. The

TABLE 3.—ANNUAL MORTALITY PER MILLION POPULATION FROM BRONCHITIS, PNEUMONIA, AND PHTHISIS IN ENGLAND AND WALES

Cause of Death	Decennial Period	15	20	25	35	45	55	65	75 and Over
				Males					
Bronchitis	1861-1870	59	107	247	671	1749	4500	10158	19901
	1871-1880	57	92	229	745	2059	5291	12234	25390
	1881-1890	42	63	155	542	1714	4737	11144	23270
	1891-1900	30	45	107	372	1296	4074	10228	22939
	1901-1910	18	26	57	191	733	2663	7449	18570
	Percentage 1871-1880 taken as 100	*31.6*	*27.8*	*24.9*	*25.6*	*35.6*	*50.3*	*60.9*	*73.1*
Pneumonia	1861-1870	169	273	387	612	896	1330	1940	2348
	1871-1880	195	337	510	886	1272	1802	2446	2787
	1901-1910	254	368	531	960	1534	2494	3761	5545
	Percentage 1871-1880 taken as 100	*130.3*	*109.2*	*104.1*	*108.4*	*120.6*	*138.3*	*153.8*	*199.0*
Phthisis	1851-1860	2398	4054	4028	4016	3840	3346	2394	927
	1871-1880	1685	3109	3713	4137	3865	3206	1928	604
	1901-1910	756	1521	1966	2446	2753	2379	1521	567
	Percentage 1871-1880 taken as 100	*34.4*	*39.0*	*47.8*	*58.7*	*71.0*	*71.8*	*74.7*	*85.5*
				Females					
Bronchitis	1861-1870	69	101	217	550	1460	4058	9753	18491
	1871-1880	62	91	213	624	1639	4767	11950	24628
	1881-1890	46	71	164	504	1412	4152	10603	23361
	1891-1900	33	45	105	362	1139	3654	9923	23506
	1901-1910	18	22	48	182	622	2291	7022	18577
	Percentage 1871-1880 taken as 100	*29.0*	*24.2*	*22.5*	*29.2*	*37.3*	*48.1*	*58.8*	*75.4*
Pneumonia	1861-1870	146	170	227	295	381	715	1275	1858
	1871-1880	151	193	287	421	518	926	1628	2103
	1901-1910	161	199	302	501	747	1440	2786	4665
	Percentage 1871-1880 taken as 100	*106.6*	*103.1*	*105.2*	*119.0*	*144.2*	*155.3*	*171.1*	*221.8*
Phthisis	1851-1860	3523	4302	4583	4197	3134	2394	1640	717
	1871-1880	3121	3972	4395	3909	2867	2075	1246	448
	1901-1910	988	1235	1475	1551	1310	1047	756	357
	Percentage 1871-1880 taken as 100	*31.7*	*31.1*	*33.6*	*32.0*	*45.7*	*50.5*	*60.7*	*79.7*

fall has been most pronounced in early adult life and least pronounced at advanced ages. The similarity between the reactions of the two sexes to this cause of mortality is shown in Figure 1. The differences in the percentage

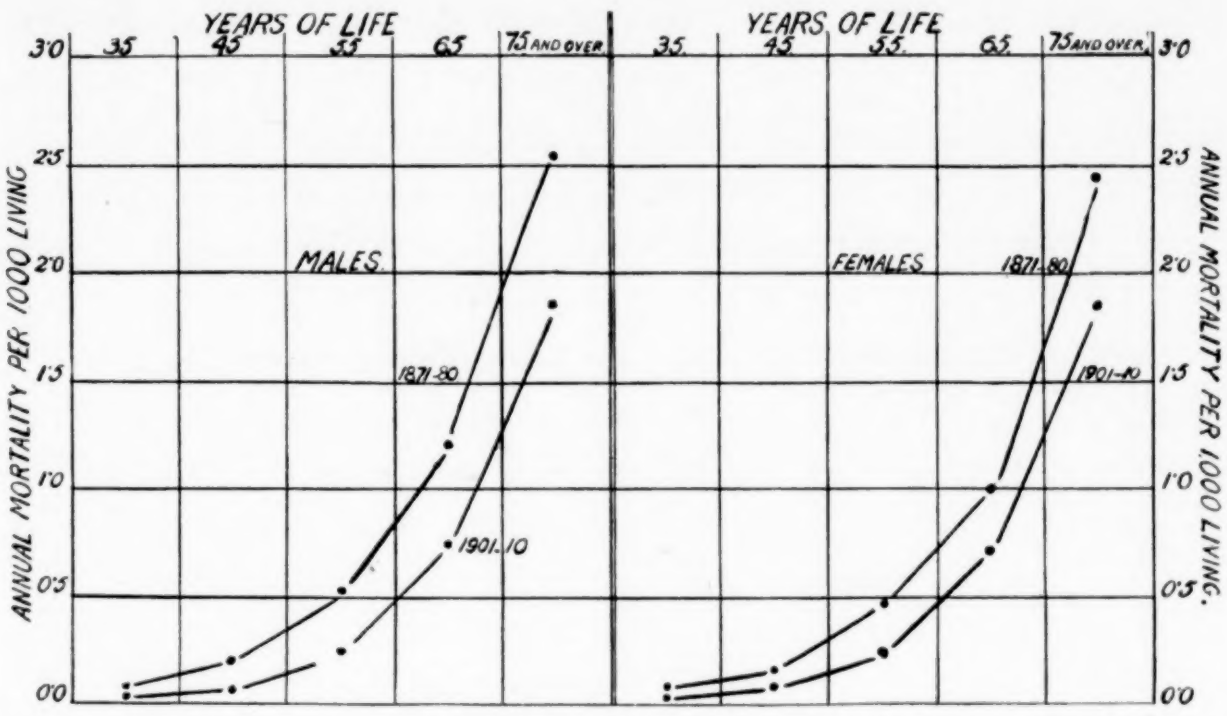

FIG. 1.—Comparative mortalities from bronchitis for males and females 35 years of age and over, 1871-1880, and 1901-1910.

fall at different periods of life are of interest, since if the fall was due to any alteration in virulence of the disease it might be expected to affect all ages alike. On the other hand, if the fall is due to alterations in the host rather than in the infecting guest, such alterations might be expected to affect different ages differently, and to affect most the more impressionable—that is, the more youthful ages. Here is support for what appears later—namely, that social uplift expresses itself physiologically in resistance to certain forms of disease, of which bronchitis is one.

The records for pneumonia show a considerable rise from 1861-1870 to 1871-1880 for both males and females at every age period; after that decennium, contrary to the course of bronchitis, the rise has continued; it has been most pronounced in the late age periods and has been greater for females than for males. The contrary

in the previous decennium. Some influence or influences which favored bronchitis up to 1870 would appear to have abated in strength steadily since that time; some influence or influences favorable to pneumonia would appear to have increased steadily in strength from 1860 onwards.

Phthisis mortality represents a third variation; it has steadily declined for both sexes since 1851-1860; it has declined much more for females than for males; it has been most pronounced in early adult life and least pronounced at advanced ages. For females the decline is only slightly less at each age than the decline in bronchitis mortality. It cannot be claimed, however, that the increase in pneumonia is, so to speak, a taking up of the slack left by the decrease in phthisis, for the phthisis fall has been greatest at those age periods at which the pneumonia increase has been least, and *vice versa*.

The contention has been advanced on clinical evidence that bronchitis prepares the way for phthisis (2). The records already quoted do not fully support this view. The mortalities for the two diseases since 1870 may be claimed in support; for the mortality from bronchitis has been falling more rapidly than that for phthisis, and at those age periods at which the fall for phthisis has been most pronounced. The phthisis rate, however, was falling from 1850 onwards, while the bronchitis rate was increasing up to 1870.

Seasonal Variations.—Mortality from bronchitis, like morbidity, shows marked seasonal variations, more pronounced for females than for males. The variations are far greater than those of deaths from all causes (see Table 4). The years 1916 and 1920 have been used for calculating seasonal variations in order to avoid a time when an influenza epidemic might have disturbed the normal course of events. The first quarter of the year has the highest mortality, and the third quarter the lowest. This seasonal distribution holds

TABLE 4.—DISTRIBUTION ACCORDING TO SEASON OF DEATHS FROM BRONCHITIS, PNEUMONIA, AND PHTHISIS, IN THE YEARS 1916 AND 1920, IN ENGLAND AND WALES

District	Cause of Death	1st Quarter	2d Quarter	3rd Quarter	4th Quarter	Year
			Males			
London	Bronchitis	371.7	201.3	99.8	327.2	1000
	Pneumonia	370.9	229.2	119.3	280.6	1000
	Phthisis	264.1	249.4	205.7	280.8	1000
	All causes	292.1	243.6	197.9	266.4	1000
County boroughs	Bronchitis	348.2	240.7	129.5	281.6	1000
	Pneumonia	345.1	277.5	142.3	236.1	1000
	Phthisis	272.9	267.2	210.5	249.4	1000
	All causes	295.9	260.0	195.4	248.7	1000
Urban districts	Bronchitis	338.4	237.6	114.1	309.9	1000
	Pneumonia	335.9	286.8	136.8	240.5	1000
	Phthisis	263.8	267.9	211.1	257.2	1000
	All causes	285.3	256.4	203.0	255.3	1000
Rural districts	Bronchitis	341.2	257.0	114.0	287.8	1000
	Pneumonia	337.2	298.4	142.6	221.6	1000
	Phthisis	267.6	287.3	212.7	232.4	
	All causes	280.7	260.0	204.9	254.4	1000
			Females			
London	Bronchitis	375.6	195.8	78.1	350.5	1000
	Pneumonia	374.9	245.7	97.5	281.9	1000
	Phthisis	275.5	256.7	209.6	258.2	1000
	All causes	282.4	240.0	190.5	287.1	1000
County boroughs	Bronchitis	361.6	222.8	104.0	311.6	1000
	Pneumonia	374.8	271.6	122.1	231.5	1000
	Phthisis	260.3	267.6	214.2	257.9	1000
	All causes	294.7	249.9	195.8	259.6	1000
Urban districts	Bronchitis	364.6	225.8	103.0	306.6	1000
	Pneumonia	346.9	280.7	130.4	242.0	1000
	Phthisis	265.6	269.7	217.9	246.8	1000
	All causes	287.6	251.7	201.0	259.7	1000
Rural districts	Bronchitis	346.5	255.4	102.5	295.6	1000
	Pneumonia	349.6	295.7	131.1	223.6	1000
	Phthisis	257.3	271.6	221.8	249.3	1000
	All causes	282.4	255.3	201.4	260.9	1000

good for males and females, and for various aggregations of population; but it is most pronounced for London with its great population and atmospheric pollution.

The seasonal distribution of pneumonia shows the same tendency as that of bronchitis, but the fall in the third quarter is not so pronounced. If deaths from lobar pneumonia alone are considered, the seasonal variations are found to be somewhat less pronounced.

Deaths from phthisis, on the other hand, while showing definite seasonal variations, have a more even distribution throughout the year than deaths from all causes. Here among the populations instanced in Table 4 the greatest number of deaths occurs in the second quarter more often than in the first, while in one case it occurs in the fourth quarter.

In this connection Dron (3) has called attention to the fall in mortality from bronchitis in Scotland during 1921, the year of the coal strike:

Period	*Deaths from Bronchitis in Scotland*	
1916-1920	(annual average)	5,000
1921		3,971
1922		5,224

Climate.—The indication given by seasonal variations can be followed up by examining local differences in mortality, since localities differ in their climates. Greenwood (4) has considered the point, choosing for the purpose Lancashire, Northants, and Cumberland. He suggests that any excess of mortality found in Cumberland over Northants may be ascribed to climate; as far as bronchitis is concerned, however, while the mortality of Cumberland ex-

TABLE 5.—RATES OF MORTALITY PER 1,000 POPULATION IN CERTAIN COUNTIES

District	Ages 45-55			Ages 55-65		
	Bronchitis	Pneumonia	Phthisis	Bronchitis	Pneumonia	Phthisis
England and Wales						
Males	0.73	1.53	2.75	2.66	2.49	2.38
Females	0.62	0.75	1.31	2.29	1.44	1.05
Lancashire						
Males	1.43	2.45	2.65	5.09	3.85	3.08
Females	1.33	1.20	1.56	4.60	2.27	1.21
Northants						
Males	0.37	0.85	1.84	1.31	1.29	1.61
Females	0.28	0.34	0.97	1.46	0.69	0.72
Cumberland						
Males	0.44	1.94	2.12	1.93	2.83	1.64
Females	0.37	0.91	1.13	1.73	1.60	0.88

Seasonal variations give some clue to conditions which conduce to the death rate from bronchitis—namely, wintry weather. Support for this deduction is to be found in the mortality from this cause, which was unduly low during the recent mild winter of 1922-1923. A mild winter means not only less severe cold but also fewer fogs which, in great cities, cause an obvious condition of atmospheric pollution.

ceeds that of Northants, the mortality of both counties is less than the standard for England and Wales. Climatic conditions may be claimed to have some influence; but Greenwood points out that Lancashire, with a climate somewhat similar to that of Cumberland, has a far higher mortality from bronchitis, and he seeks for an explanation in the industrial character of Lancashire.

The death rates for pneumonia ex-

hibit the same phenomena, only more distinctly; Cumberland suffers more for both sexes than Northants and than the standard for England and Wales; Lancashire is even more manifestly at the top.

The phthisis rates place the three counties in the same order; but the differences are smaller than for the other two respiratory diseases. For this disease the excess of Lancashire over England and Wales is not pronounced; while the rates for both the other counties are below the standard. Here is the same indication as was found from seasonal variations—namely, that the phthisis death rate is not influenced to the same extent by climate.

dustrial influence, which reaches its maximum in middle life. Phthisis mortalities show still greater differences, which, particularly in industrial urban counties, are maintained until late in life.

The suggestion which emerges is that, in the main, industrial occupations do not exert as profound an influence upon the mortality from bronchitis as upon the mortalities from phthisis and pneumonia. This suggestion receives support from the male and female mortalities from bronchitis particularly in industrial counties and in selected rural counties. The difference between the two sexes is so slight as to be negligible; but the difference between the two

TABLE 6.—MORTALITY OF MALES, 1901-1910, WHEN THAT OF FEMALES IS TAKEN AS 100

Cause of Death	15	20	25	35	45	55	65	75 and Over
Bronchitis	100.0	113.6	111.8	104.9	117.8	116.2	106.1	100.0
Pneumonia	157.8	184.9	175.5	191.6	202.3	166.3	135.0	114.6
Phthisis, Urban counties	80.6	132.0	135.3	165.1	227.3	253.9	237.2	164.0
Phthisis, Rural counties	63.9	113.3	122.4	137.9	170.6	171.8	155.7	138.9

Industrial Environment.—The influence of industrial environment may be estimated by comparing the mortality from bronchitis in the two sexes. The importance of such comparison lies in the fact that the female represents more particularly the influence of the home, while the male, who spends more of his time in outside occupations, represents more particularly industrial environment. (See Table 6.)

Attention has already been directed to the occurrence of a rather heavier mortality from bronchitis among males than among females (see Fig. 1). When the two mortalities are compared at different ages, the excess among males is found to be greatest for ages 45 to 64, after which it diminishes; but the excess is not great at any age.

This test, when applied to mortality from pneumonia, exhibits a greater insets of counties is decided for both sexes, and may be interpreted to represent the influence of industrial surroundings upon atmospheric pollution. In 1891-1900 the average mortality from bronchitis per million in selected urban and rural counties was as follows:

Sex	*Urban Counties*	*Rural Counties*	*England and Wales*
Males	2,052	1,540	1,849
Females	2,007	1,498	1,775

Every indication obtained so far from mortality statistics points to atmospheric conditions as exerting a powerful influence upon bronchitis, particularly with regard to pollution by smoke, while climatic conditions come second. The subject can be more intensively investigated by considering the mortality occurring among males when distributed by occupation.

Occupational Records

Information of considerable value is to be found in the *Decennial Supplements* of the Registrar-General, which deal with occupational mortality (5). In these publications comparative mortality figures are given for each of the occupations dealt with and, by using these, the mortality from various causes of death in different occupations may be contrasted. These comparative figures refer only to ages 25 to 64; hence, since the late period of life after 65 (already shown to be mainly concerned with bronchitis), is not included, the figures do not fully represent the extent to which bronchitis is present. This point is made clear by comparing the mortality rates per 1,000 living at different ages for the clergy and for potters at two decennial periods.

Occupation	*Age Period*			
	35	45	55	65 and Over
Clergy				
1890-92	0.04	0.21	0.85	6.56
1910-12	0.00	0.00	0.49	3.77
Potters				
1890-92	2.51	10.65	22.26	31.47
1910-12	0.83	3.56	10.24	22.10

Nevertheless, if this point is kept in mind, comparative mortality figures may be used as some indication of the prevalence of bronchitis in different occupational groups. With this end in view certain comparative figures, extracted from the last three *Supplements*, have been placed together in Table 7, which has been constructed to illustrate definite points. The standard for comparison for each disease and at each period is the comparative figure for All Males. It is seen that the mortality from bronchitis has fallen in a marked way in every occupation quoted, and that the fall has been most marked where the mortality was highest in 1890-1892. There is here evidence that some general influence for the better, apart from occupational environment, has been at work during the thirty years. Probably this influence is the same as that which has determined the rather smaller fall in phthisis mortality, and may be ascribed to general improvement in health, associated with a general rise in social conditions of which the value of real wages may be taken as the index.

Year	*Consumption of Food and Other Necessities*	*Real Wages*	*Comparative Mortality from Bronchitis All Males*
1890	109	88	
1891	113	89	101
1892	115	90	
1900	120	96	
1901	119	97	57
1902	119	99	
1910	119	100	
1911	120	100	32
1912	122	98	

This suggestion receives support from the comparative figures for the great social groups, in which the mortality from bronchitis is seen to increase steadily as the social status is lowered, until among unskilled workmen it is more than four times that of the upper and middle classes. This phenomenon, it may be noted, is even more marked for bronchitis than for phthisis, pneumonia, or the death rate from all causes (Table 8). The contrast is even greater if the figures are considered for the occupations into which the failures of the occupational world, whether due to lack of skill or to breakdown in health, tend to drift,—for example, dock laborers, costermongers, and general laborers.

Social status must then be looked upon as an important factor in deter-

TABLE 7.—COMPARATIVE MORTALITY IN ENGLAND AND WALES FROM BRONCHITIS, PNEUMONIA, AND PHTHISIS, OF MALES, AGED 25-64, IN CERTAIN OCCUPATIONS FOR THREE DECENNIAL PERIODS

Period	i[1]	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
	Professions											
	Clergy			Doctors			Lawyers			Schoolmasters		
1890-92	12	51	77	14	108	121	19	64	135	25	50	129
1900-02	7	34	55	13	91	65	15	51	92	16	47	113
1910-12	5	28	45	9	67	64	7	45	58	10	43	70
	Outdoor Life											
	Farmers			Agricultural Laborers			Fishermen			Gardeners		
1890-92	29	57	92	53	76	135	48	63	133	47	55	131
1900-02	14	47	76	26	54	90	27	62	100	27	45	88
1910-12	11	43	56	14	40	70	20	55	101	15	32	76
	Indoor Life											
	Chemists			Ironmongers			Grocers			Indoor Domestics		
1890-92	34	86	210	41	100	140	54	63	154	47	70	215
1900-02	36	68	149	28	45	135	30	43	125	40	63	199
1910-12	20	64	93	18	40	95	25	35	96	31	45	136
	Indoor Industries											
	Lace Makers			Tailors			Printers			Shoemakers		
1890-92	46	55	186	108	87	314	118	94	378	95	85	297
1900-02	35	60	206	61	61	248	47	64	300	59	68	271
1910-12	19	43	157	38	55	186	31	50	208	40	53	222
	Alcohol Trade									ALL MALES		
	Innkeepers			Innservants			Brewers					
1890-92	96	183	300	136	228	552	132	166	317	*101*	*123*	*223*
1900-02	57	147	271	90	191	543	96	96	248	*57*	*90*	*186*
1910-12	27	104	196	51	115	309	45	95	181	*38*	*66*	*142*
	Coal Trade											
	All Coal Miners			Coal Miners						Coal Heavers		
				Lancashire			Northumberland and Durham					
1890-92	131	141	113	198	217	118	58	85	109	207	287	250
1900-02	79	86	89	113	149	96	41	54	84	91	157	213
1910-12	50	65	75	88	100	107	33	54	70	54	116	169

[1] (i) = bronchitis; (ii) = pneumonia; (iii) = phthisis.

mining the prevalence of bronchitis, and may account for the low mortality for each of the respiratory dieases experienced by the professional group. Nevertheless, attention is challenged by the great fall which has occurred in the professional group during the thirty years with regard to mortalities from respiratory diseases, especially that from bronchitis. The claim can hardly be ad-

TABLE 7.—(*Continued*)

Period	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
	Exposure to Heat and (or) Fume											
	Chemical Manufacturers			Glass Makers			Gasworks Service			Textile Dyers		
1890-92	286	236	188	257	218	343	163	185	213	175	205	303
1900-02	120	148	98	132	104	283	72	121	141	81	110	193
1910-12	58	89	71	85	73	184	51	67	119	48	74	139
	Exposure to Animal Dust											
	Silk Manufacturers			Woolen Operatives			Harness Makers and Saddlers			Carpet Makers		
1890-92	114	124	226	121	138	221	83	84	276	146	114	263
1900-02	43	30	219	56	83	159	45	66	224	54	99	180
1910-12	34	29	126	37	55	124	29	50	154	40	48	115
	Exposure to Vegetable Dust											
	Millers			Cotton Operatives			Rope Makers			Carpenters		
1890-92	108	93	165	171	182	233	167	112	254	68	86	200
1900-02	71	84	129	92	109	197	82	78	207	39	68	150
1910-12	36	58	92	55	70	120	38	47	124	25	54	128
				150[2]	113[2]	155[2]						
	Exposure to Inorganic Dust, Group 1											
	Brick Makers			Cement Makers			Limestone Masons					
1890-92	92	118	97	———			———					
1900-02	47	69	76	———			———					
1910-12	25	67	73	14	66	88	38	54	129			
	Exposure to Inorganic Dust, Group 2											
	Potters			Cutlers			Sandstone Masons			Tin Miners		
1890-92	435	155	385	305	237	442	———			166	123	586
1900-02	253	105	285	132	136	533	———			206	81	816
1910-12	168	95	282	82	85	466	116	120	415	76	95	678
	Unskilled Labor											
	Dock Laborers			Costermongers			General Laborers					
1890-92	329	254	377	221	197	514	162	191	295			
1900-02	137	187	308	165	177	554	145	245	491			
1910-12	81	140	231	104	142	419	———					

[2] These figures refer to cotton strippers.

vanced that the health environment of this group has altered sufficiently to account for the fall. An indication may be found here that the community exists as a whole, and that the interplay of social grades is such that what benefits one grade in particular reacts to the benefit of all grades, although perhaps not so intensely. If this suggestion is true, then no grade of the community

can afford to disregard the health of any other grade. After allowance has been made for such factors, the occupational groups instanced in Table 7 show certain interesting points.

TABLE 8.—COMPARATIVE MORTALITY IN ENGLAND AND WALES, AGES 25-64, IN CERTAIN SOCIAL CLASSES FROM ALL CAUSES AND FROM RESPIRATORY DISEASES, 1910-1912

Cause of Death	Social Class			
	Upper and Middle	Intermediate	Skilled Workmen	Unskilled Workmen
(1) Bronchitis	16	26	37	71
(2) Pneumonia	47	58	57	115
(3) Phthisis	121	123	155	215
All causes	695	745	758	1121

1. The outdoor and indoor life groups exhibit low mortalities for each respiratory disease; but the outdoor group is distinctly below the indoor for phthisis and also, although to a lesser extent, for pneumonia.

2. Indoor industries experience a low mortality for bronchitis and for pneumonia; but the phthisis figure is high. Here it is apparent that the three respiratory diseases do not of necessity rise or fall together.

3. For coal miners generally the phthisis rate is low (but not for coal heavers); the bronchitis and pneumonia rates generally are high, but on some fields—for instance, Northumberland and Durham—they are low, and on those fields the phthisis rate is particularly low. Close investigation of available data (6) has brought out that men at the coal face experience higher mortalities from phthisis, pneumonia, and bronchitis, than do other miners; and the idea emerges that the causative factor is exposure to dust composed of the rocks with which the coal is found, or of certain kinds of coal.

4. The alcohol trade experiences a high mortality from phthisis, which is highest where the social status is lowest. The pneumonia rate is similar, but for bronchitis the excess is not pronounced.

5. Exposure to heat and fumes seems to have a definitely bad effect with regard to bronchitis, and a similar, although less pronounced, effect with regard to pneumonia. Here phthisis is low in the chemical trade and the gas-works service, where the conditions may be inimical to the spread of infection; but it is high for glass makers and (until 1910-1912) for textile dyers.

6. Exposure to dusts of animal origin is not found associated with any pronounced excess of either of the respiratory diseases (if we omit some excess of phthisis among harness makers).

7. Bronchitis is in excess among cotton operatives and rope makers. Probably, if the evidence of mortality is accepted for the subdivision, cotton strippers, with their peculiar exposure to dust, the cause must be ascribed to exposure to dust of vegetable husks and débris. The cotton operative also has rather a high figure for pneumonia. Millers and carpenters show no excess for either bronchitis or pneumonia; and no occupation in this group is high for phthisis.

8. Certain inorganic dusts are not found associated with any high mortality from either of the respiratory diseases; but other inorganic dusts, all of which contain free silica, are associated with high and excessive mortalities for each of these diseases.

9. There is evidence, drawn from other sources and quoted at length elsewhere (7), that other inorganic dusts, such as emery and carborundum, cause bronchitis and possibly pneumonia without influencing the phthisis mortali-

ty; but as no group given in the occupational supplements represents exposure to these risks no figures are here instanced in support.

Exposure	*Bronchitis*	*Pneumonia*	*Phthisis*
Outdoor and indoor life	low	low	low
Indoor industries	low	low	high
Coal trade	high	high	low
Alcohol trade	moderate	high	high
Heat and fumes	high	high	low
Dust of (i) animal origin; (ii) vegetable husks and débris; certain inorganic materials;	high	medium	low
(iii) silica	high	high	high

A review of the evidence indicates that a high mortality from bronchitis and one from pneumonia tend to go together, but the association is not absolute. On the other hand, the prevalence of phthisis shows no pronounced tendency to vary with that of either disease.

The particular influence associated in occupations with a high mortality from bronchitis is exposure to certain inorganic or vegetable dusts. In other words, the chief of the pneumonokonioses is bronchitis, rather than dust-phthisis, which is only associated with a few kinds of dust, and in particular with those containing free silica. To this dust influence must be added exposure to fumes and to heat before furnaces.

Summary

1. Bronchitis in England and Wales contributes so much to morbidity and mortality as to make it the most important of diseases. It is responsible annually for about 80,000 years of invalidity, and for about 28,600 deaths at ages 15 and over.

2. The mortality from this disease particularly concerns late life; it has tended to be somewhat heavier for males than for females.

3. It has been falling rapidly since 1870, and rather more for males than for females. The fall has been greatest where the mortality formerly was highest; thus, it has been greatest in the lower grades of the industrial community.

4. Records indicate that bronchitis is a disease entity which varies independently of pneumonia or phthisis.

5. Bronchitis is conduced to by severe climatic conditions, such as wintry weather, and more particularly by atmospheric pollution.

6. Industrial work does not exert so profound an influence upon bronchitis as upon pneumonia or phthisis; there is no evidence that aggregation of persons in industry is an influence in the spread of the disease, as in the case of phthisis.

7. Occupations which entail exposure to atmospheric pollution, whether through irritating gases or through injurious dust, carry with them risk of bronchitis.

8. Generally, records of mortality from bronchitis exhibit indications of a chronic traumatic origin for the disease associated with irritating atmospheric conditions, rather than of an infectious origin.

Conclusion

Reduction in morbidity and mortality from bronchitis is to be sought for in two directions: (1) in social uplift, that is, by such increase of health in the lower grades of society as establishes resistance to disease; and (2) in smoke abatement, particularly in industrial districts and great towns.

BIBLIOGRAPHY

1. Sickness Frequency among Industrial Employees. U. S. Pub. Health Rep., 1922, *37*, 2. Incidence of Serious Morbidity among a Group of Wage Earners. *Ibid.*, p. 3195.
2. McClure, J. C.: The Association of Bronchitis with Pulmonary Tuberculosis. Tubercle, 1923, *4*.
3. Dron, R. W.: Smoke and Health. The Times, May 15, 1923.
4. Greenwood, M.: Influence of Industrial Employment upon General Health. Milroy Lectures, 1922. Brit. Med. Jour., 1922, *1*, 667, 708, and 752.
5. (a) Supplement to Fifty-Fifth Annual Report of Registrar-General, Part II. (C.-8503), 1897. (b) Supplement to Sixty-Fifth Annual Report of Registrar-General, Part II. (Cd. 2619), 1908. (c) Supplement to Seventy-Fifth Annual Report of Registrar-General, Part IV., 1913. H. M. Stationery Office.
6. Collis, E. L.: A Study of the Mortality of Coal Miners, England and Wales. THIS JOUR., 1922-1923, *4*, 256, 307.
7. Collis, E. L.: Industrial Pneumonoconiosis, with Special Reference to Dust-Phthisis. Milroy Lectures, 1915. Pub. Health, 1914-1915, 28, 252; H. M. Stationery Office, 1919.
8. Eighty-Third Annual Report of the Registrar-General.
9. Seventy-Ninth Annual Report of the Registrar-General.

BOOK REVIEW

L'HYGIENE DE L'OEIL ET LE TRAVAIL INDUSTRIEL. Pp. 160 with appendix. Geneva: International Labour Office, June, 1923.

This is Number 6 of the "Etudes et Documents" issued by the International Labour Office from Geneva. It deals with the problems of industrial lighting, and summarizes the present knowledge of the subject. A large number of references is given and extracts are made. The bulk of the document, however, is written impersonally and is unsigned.

In the introduction the problem of lighting is stated to be the health of the retina, and attention is called to the large field open to research in the study of the normal function of the eye and its reaction to the lighting conditions present. Throughout the report stress is laid on the propaganda in the States, and on the conclusions of the English Departmental Committee on Lighting. The aims of effective lighting are cleanliness, prevention of fatigue, prevention of accidents, discipline and easy control, prevention of confusion, improvement and quicker execution of work.

The first section deals with sources of illumination and gives the definitions adopted by the International Commission. The unit of luminous intensity is the international candle. Luminous flux, surface brightness, and other definitions are given in full. The great importance of photometry is emphasized. The light from the sky, split up by the myriad facets of the particles of dust floating in the atmosphere, is diffuse. Sunlight is very rich in ultraviolet and blue rays which are generally lacking in artificial light. Natural lighting is very variable, and the intensity of 4,000 foot-candles in midsummer falls to a little over 500 in midwinter. Good natural lighting should reach the center of the working area in the greatest possible amount, at the most useful angle, and diffusely. The surroundings should absorb as little incident light as possible; and abrupt shadows should be avoided.

In artificial lighting the brighter the light the higher the temperature, and the more intense the source of illumination the further the spectrum extends toward the violet rays, with resulting danger from the chemical rays. The essentials of an artificial source of light are: (*a*) it should be easily employed and of a low cost; (*b*) it should resemble daylight as far as possible—above all it should be diffuse and not modify the natural colors of objects; (*c*) it should be of moderate intensity and illuminate a sufficiently wide area; (*d*) it should not greatly increase the temperature or alter the composition of the air with products of combustion. In practice illumination should be diffuse, sufficient, and constant. It may be direct, semi-indirect, or indirect. Indirect lighting is more agreeable to the eye but costs three times as much as direct lighting. By using light colors for the walls and white translucent china reflectors this extra cost may be reduced. Mercury vapor lamps give the most diffuse light and are best used in combination with local lighting over the working area.

Instruction is given in the spacing of lamps and the use of the various reflectors and globes. It is important to place the lamp so that the reflected ray from the working area passes in front of the workman's head; the source should be so shaded that no direct rays fall into the eyes. The amount of illumination for a working area should be sufficient to allow the workman to continue his employment for a long time without fatigue. Great contrasts between local and general lighting should be avoided. Passages should have 1 lux; working places 10 to 25 lux, according to the nature of the work. Broca demands 20 to 40 lux for schools.

The second section of the study considers lighting with reference to the nature of the work at which persons are employed. Here the amount of reflected light is of first importance. A worker on black velvet requires at least three times the illumination supplied to those working with white material. Surfaces with sheen or metallic luster give rise to great trouble from glare.

In the third section the action of light on the eye is discussed. A distinction is drawn

between physiological and professional visual acuity. Professional visual acuity is represented by the smallest amount of physiological visual acuity which allows a man to carry out his employment easily and without danger. Where high visual acuity is required, from three-quarters to one-sixth of physiological visual acuity gives adequate vision. Ordinary work can be carried out with one-half to one-tenth of normal vision.

The color of the light employed has an effect on the worker. Under a red light men become excitable, nervous, and irritable; yellow light is the most agreeable; while green and blue have a sedative action. Violet and ultraviolet lights cause headaches, unrest, and giddiness.

The fourth section deals with ocular fatigue of which the pathology is little known and which offers a great field for research. A large number of reflex actions are bound up with vision and unless these function properly, separately and in combination, vision is not normal. The alteration of the reflexes is shown by photophobia, blinking, and orbital pain leading eventually to closure of the eyes. The direct causes of ocular fatigue are: (*a*) bad light leading to excessive accommodation and convergence; (*b*) faulty position at work; (*c*) insufficient lighting; (*d*) direct lighting with glare; (*e*) character of work—rapidity, sheen, accuracy demanded; (*f*) unsteadiness of source of light; and (*g*) ultraviolet rays. Ocular fatigue in miners has been investigated by Stassen and Kirk. Kirk found 142 cases of myopia or myopic astigmatism in an examination of several thousand young miners, with only three cases of nystagmus. He attributes the myopia to the work.

Most of the ultraviolet rays of the sun are absorbed by the atmosphere and the crystalline lens. The action on the retina is almost negligible. The short ultraviolet rays cause photophobia and inflammation of the lids and conjunctiva. Heat rays do not reach the retina but favor the action of other injurious rays on the lens. All these rays can be negatived by the use of protecting glass of which the most important is that known as "Crookes."

In the fifth section the relationship between lighting and accidents is treated. Industrial accidents vary inversely with the amount of sunlight, being more frequent in November and December. Accidents are more frequent in night shifts than on day work. Several insurance companies estimate that 25 per cent. of all accidents are due to bad light.

In the section on prophylaxis of ocular fatigue the necessity for examination at school and medical advice on suitability of occupation are insisted upon. Careful examination before employment will check unjust claims on the employer. In large works arrangements should be made for the periodic visits of ophthalmic specialists; smaller works should combine to secure for their workmen similar facilities at an ophthalmic clinic. The use of protecting goggles is advocated. These goggles should be easy to apply, light but firm, and cheap; they should not limit the visual field or make the eyes warm.

The final section deals with the regulations of industrial lighting. The codes of several of the States and of the British and German commissions are given in tabular form. The necessity for international agreement and the advisability of pooling the resources of the various nations are emphasized.

An appendix deals with the legislation of the different countries, and many extracts are given of safety-first regulations and other codes.

The document will well repay study and is of special interest in advancing one aspect of the League of Nations on which all may agree.—*T. L. Llewellyn.*